Laboratory Manual of General Chemistry

Williams

LABORATORY MANUAL

OF

GENERAL CHEMISTRY.

INCLUDING

DIRECTIONS FOR PERFORMING ONE HUNDRED OF THE MORE IMPORTANT EXPERIMENTS IN GENERAL CHEMISTRY AND METAL ANALYSIS, WITH BLANKS AND A MODEL FOR THE SAME, LABORATORY RULES AND SUGGESTIONS, AND TABLES OF ELEMENTS, COMPOUNDS, SOLUTIONS, APPARATUS, AND CHEMICALS.

PREPARED FOR USE WITH ANY TEXT-BOOK OF CHEMISTRY; SPECIALLY ADAPTED TO ACCOMPANY "INTRODUCTION TO CHEMICAL SCIENCE."

BY

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APPARATUS FOR EACH LOCKER.

[Apparatus and Chemicals can be obtained of Dr. A. P. Gage, Boston. "Introduction to Chemical Science" is published by Ginn & Co., Boston].

2 horseradish (or olive) bottles, and corks to fit.
1 soda bottle.
2 pieces window glass (3 in. sq.).
2 pieces glass tubing (20 in. long, $\frac{1}{4}$ in. diam.).
1 glass stirring-rod.
1 glass funnel (3 in., 60°).
1 piece ignition tubing (12 in. long, $\frac{1}{2}$ in. diam.).
1 porcelain evaporating dish (3 in. wide).
1 asbestus paper, or wire gauze (3 in. sq.).
1 iron (or tin) plate (5 or 6 in. diam.).
1 pair forceps.
1 three-cornered file.
1 round file.
1 copper wire (15 in. long).
6 test tubes, and corks to fit.
1 wooden test-tube holder.
1 thistle-tube.

APPARATUS FOR GENERAL USE.

Flasks (200^{cc}).
Bunsen burners.
Rubber tubing (18 in. long, $\frac{1}{4}$ in. diam., inside).
Iron ring-stands.
Reagent bottles (250 and 500^{cc}).
Metric rulers (30^{cm} long).
Graduates (25^{cc} and 200^{cc}).
Scales with metric weights (1–100^{g}).
Pneumatic troughs.
Glass tubing ($\frac{1}{4}$ in. outside diam.).
Glass tubing ($\frac{3}{4}$ in. diam.), 2 lbs.
Hessian crucibles (50 or 100^{cc}).
Beakers (25 or 50^{cc} and 2000^{cc}).
Lead trays (5 or 6^{cm} sq., 1 deep).
Mortars and pestles.
Fine wire gauze (No. 50 or 60, 3 in. sq.).
Platinum wire (No. 23).
Blow-pipes.
Bricks.

CHEMICALS.

Estimates for a Class of Twenty.

Acetic acid	2 lb.	Litmus paper	2 ft.
Alcohol	2 lb.	Magnesium chloride	2 oz.
Alum	4 oz.	Magnesium ribbon	2 ft.
Ammonium carbonate	2 oz.	Manganese chloride	2 oz.
Ammonium chloride	1 lb.	Manganese dioxide	1 lb.
Ammonium hydrate	4 lb.	Magnesium sulphate	1 oz.
Ammonium nitrate	1 lb.	Marble	2 lb.
Ammonium oxalate	2 oz.	Mercuric chloride	2 oz.
Ammonium sulphate	4 oz.	Mercurous nitrate	2 oz.
Antimony (metallic)	½ oz.	Molasses	1 pt.
Antimony chloride	2 oz.	Naphtha	1 lb.
Arsenic (metallic)	¼ oz.	Nitric acid	7 lb.
Arsenic teroxide	½ oz.	Nickel sulphate	1 oz.
Barium chloride	3 oz.	Phosphorus	¼ lb.
Barium nitrate	1 oz.	Picture wire	7 ft.
Beeswax	3 oz.	Potassium (metallic)	⅛ oz.
Bi-carbonate of soda	2 oz.	Potassium bi-chromate	4 oz.
Bismuth chloride	2 oz.	Potassium bromide	2 oz.
Bleaching-powder	½ lb.	Potassium chlorate	2 lb.
Bone-black	½ lb.	Potassium chromate	1 oz.
Brimstone	1½ lb.	Potassium cyanide	1 oz.
Calcium chloride	2 oz.	Potassium ferrocyanide	2 oz.
Calcium sulphate	1 oz.	Potassium hydrate	½ lb.
Candles	——	Potassium iodide	2 oz.
Cannel coal	½ lb.	Potassium nitrate	½ lb.
Carbon bisulphide	2 oz.	Potassium nitrite	2 oz.
Charcoal	½ lb.	Silver nitrate	1 oz.
Cobalt nitrate	½ oz.	Soap	½ lb.
Cochineal	¼ oz.	Sodium (metallic)	½ oz.
Coins	——	Sodium arsenite	2 oz.
Copper (filings or turnings)	1 lb.	Sodium carbonate	1 lb.
Copper nitrate	3 oz.	Sodium chloride	1 lb.
Copper oxide	2 oz.	Sodium hydrate	1 lb.
Chlorhydric acid	10 lb.	Sodium hyposulphite	½ lb.
Ferrous sulphate	4 oz.	Sodium nitrate	½ lb.
Ferrous sulphide	3 lb.	Sodium sulphite	1 oz.
Filter papers (4 in.)	1000	Sodium phosphate	3 oz.
Fluor spar (powdered)	3 oz.	Starch	½ lb.
Fuming sulphuric acid	¼ lb.	Strontium chloride	1 oz.
Gold leaf	4 in. sq.	Sugar	½ lb.
Indigo	1 oz.	Sulphuric acid	12 lb.
Iodine	½ oz.	Tin chloride	2 oz.
Lead	½ lb.	Turkey red cloth	⅓ yd.
Lead acetate	2 oz.	Turpentine (spirits)	1 oz.
Lead nitrate	½ lb.	Water glass	1 lb.
Lead protoxide	1 oz.	Yeast	1 cake
Lime (unslaked)	1 lb.	Zinc	1 lb.
Litmus	1 oz.	Zinc sulphate	2 oz.

RULES AND SUGGESTIONS FOR THE LABORATORY.

1. Each pupil must furnish a cloth or sponge to keep his table clean, and any apron or other clothing desired for use in the laboratory. These latter are indispensable for preserving the clothing.

2. The table occupied by pupils must be left clean and dry after every laboratory exercise. Wash and wipe dry a ring stand, or any other apparatus on which a reagent has fallen, wipe out a p.t. after using it, and keep reagent bottles, other apparatus, books, and lockers clean.

3. Pupils are held responsible for apparatus, and must replace anything that is broken or lost.

4. Have every d.t. and stopper fit tightly, to prevent leakage of gas.

5. In heating a t.t. on the r.s., hold the lamp in the hand, moving it slowly.

6. Mixtures of solids should be made on paper or in an e.d. Be careful not to mix chemicals or reagents except as directed.

7. To shake the contents of a t.t., cover its mouth with the thumb or the hand, hold it away from the table, and shake it vigorously.

8. Never put down a stopper when using a reagent bottle, but hold it between the first and second fingers, and replace it as soon as you are through using it. Do not pour back any excess of a reagent from a t.t. or other rec. into a reagent bottle, and do not dip a stirring-rod into a reagent bottle.

9. In pouring a liquid into a graduate or t.t., hold the latter on a level with the eye, placing the thumb-nail at the upper limit to which it is desired the liquid should reach.

10. Pour only liquids or fine powders into the bowls, always opening the jet at first, to let the water run. Solids should be thrown into the jars.

11. Have flasks and t.t. perfectly dry on the outside before applying heat. If there are no racks for t.t., they may conveniently rest in the rec. when not in use.

12. Reagents for general use must not be taken to the individual's table, but must be left at the side-table.

13. In experimenting, follow the directions as closely as possible. Read an exp. through before performing any part of it. Ask an explanation of anything you do not understand.

14. Read the "Model for Taking Notes." Begin to write your notes on the page opposite the exp. Both name and symbolize substances once in each exp.; as, manganese dioxide, MnO_2. After that use the symbols only. In writing equations, use only symbols.

15. In memorizing exps., learn names, symbols, processes, products, and reactions. Do not try to remember quantities.

16. Try to enter into the spirit of the work, by making close observations, and ascertaining what each exp. teaches. Always state whether heat has to be applied, whether the action is vigorous, and what is the color and what the state of the product.

17. No notes are to be written in this book outside of the laboratory, without special permission. Books must be brought to the teacher for inspection after each exp., and must be left in the laboratory at the end of the hour.

18. With the book closed, write your name and the division to which you belong distinctly across the front edge, in Roman letters.

19. For burns, put some dried Na_2CO_3 or $HNaCO_3$ on a handkerchief, moisten it, and bind it on the part affected. If taken in season no blister need occur, and the pain is soon allayed.

MODEL FOR TAKING NOTES.

49. To Make Nitrogen Protoxide.

I led a d.t. from a flask to a large t.t. immersed in water, and from this another d.t. to a p.t.

I put into the flask 10^g ammonium nitrate, NH_4NO_3, and heated.

At first the NH_4NO_3 melted, then a gas appeared to come off. A liquid collected in the bottle. This I found to be neutral to litmus, but it tasted like NH_4NO_3. I concluded it was water and NH_4NO_3. A colorless gas collected in the rec. over water. It was nitrogen protoxide, N_2O.

NH_4NO_3 had been separated into H_2O and N_2O.

$NH_4NO_3 = 2\,H_2O + N_2O$.

ABBREVIATIONS.

ap. — Apparatus.
cc. — Cubic centimeter.
ch. — Chemicals.
cm. — Centimeter.
def. sp. — Deflagrating spoon.
dil. — Dilute.
down. disp. — Downward displacement.
d.t. — Delivery tube.
e.d. — Evaporating dish.
exp. — Experiment.
g. — Gram.
gen. — Generator.
i.t. — Ignition tube.
lit. — Litmus paper.
ppd. — Precipitated.
ppn. — Precipitation.
ppt. — Precipitate.
p.t. — Pneumatic trough.
rec. — Receiver.
r.s. — Ring stand.
sat. — Saturated.
sol. — Solution (aqueous).
st.r. — Stirring rod.
t.t. — Test tube.
up. disp. — Upward displacement.

TABLE OF ELEMENTS.

	NAME.	SYM.	VAL.	AT. WT.	V.D.	STATE.
Negative or Non-metallic Elements. Acid-forming with H (usually OH).	Oxygen	O	II	16	16	G
	Sulphur	S	II, IV, (VI)	32	32	S
	Nitrogen	N	(I), III, V	14	14	G
	Fluorine	F	I, (V)	19		G
	Chlorine	Cl	I, (V)	35.5	35.5	G
	Bromine	Br	I, (V)	80	80	L
	Iodine	I	I, (V)	127	127	S
	Phosphorus	P	(I), III, V	31	62	S
	Arsenic	As	III, V	75	150	S
	Carbon	C	(II), IV	12		S
	Antimony	Sb	III, V	122		S
	Silicon	Si	IV	28		S
	Hydrogen	H	I	1	1	G
Positive or Metallic Elements. Base-forming with OH.	Gold	Au	(I), III	196		S
	Platinum	Pt	(II), IV	197		S
	Mercury	Hg	II	200	100	L
	Silver	Ag	I	108		S
	Copper	Cu	II	63		S
	Tin	Sn	II, IV	118		S
	Lead	Pb	II, IV	206		S
	Iron	Fe	II, IV, (VI)	56		S
	Zinc	Zn	II	65	32½	S
	Manganese	Mn	II, IV, VI	55		S
	Aluminium	Al	(II), IV	27		S
	Magnesium	Mg	II	24		S
	Calcium	Ca	II	40		S
	Barium	Ba	II	137		S
	Sodium	Na	I	23		S
	Potassium	K	I	39		S

SYMBOLS AND NAMES.

Ag_2Br	Silver sub-bromide.	
$AgBr$	" bromide.	
Ag_2Cl	" sub-chloride.	
$AgCl$	" chloride.	
$AgNO_3$	" nitrate.	Lunar caustic.
Ag_2S	" sulphide.	
$Al_2(OH)_6$	Aluminium hydrate.	
$AsCl_3$	Arsenic chloride.	
As_2O_3	" trioxide.	Arsenious anhydride, white arsenic.
As_2S_3	" sulphide.	
$AuCl_3$	Gold chloride.	
$BaCrO_4$	Barium chromate.	
$BaCl_2$	" chloride.	Muriate of baryta.
$BaCO_3$	" carbonate.	Carbonate of baryta.
$Ba(NO_3)_2$	" nitrate.	Nitrate of baryta.
$BaSO_4$	" sulphate.	Sulphate of baryta.
$Bi(NO_3)_2$	Bismuth nitrate.	
$Bi(OH)_2$	" hydrate.	
Bi_2S_3	" sulphide.	
$C_{10}H_{16}$	Turpentine (hydrocarbon).	Spirits of turpentine.
$C_6H_{10}O_5$	Starch (carbo-hydrate).	
$C_{12}H_{22}O_{11}$	Sucrose (carbo-hydrate).	Sugar.
$C_{18}H_{30}O_{15}$	Cellulose (carbo-hydrate).	Woody fiber.
C_2H_5OH	Ethyl hydrate.	Alcohol.
CO	Carbon protoxide.	Carbonic oxide.
CO_2	" dioxide.	Carbonic acid gas.
CS_2	" disulphide.	Bisulphide of carbon.
CaC_2O_4	Calcium oxalate.	
$CaCO_3$	" carbonate.	Carbonate of lime, limestone.
$Ca(ClO)_2$	" hypochlorite.	Bleaching powder ($Ca(ClO)_2 + CaCl_2$).
CaF_2	" fluoride.	Fluor spar, fluorite.
CaO	" oxide.	Unslaked lime, quick lime.
$Ca(OH)_2$	" hydrate.	Slaked lime.
$CaSO_4$	" sulphate.	Sulphate of lime.

$Co(OH)_2$	Cobalt hydrate.	
CoS	" sulphide.	
$Cr_2(NO_3)_6$	Chromic nitrate.	
$Cr_2(OH)_6$	" hydrate.	
$CuCl_2$	Cupric chloride.	
$Cu(NO_3)_2$	" nitrate.	
CuO	" oxide.	Black oxide of copper.
CuS	" sulphide.	
$CuSO_4$	" sulphate.	Blue vitriol.
$Cu_2Fe(CN)_6$	Copper ferrocyanide	
$FeCl_2$	Ferrous chloride.	
$Fe_2(NO_3)_6$	Ferric nitrate.	
Fe_3O_4	" peroxide.	Magnetic oxide, magnetite.
$Fe(OH)_2$	Ferrous hydrate.	
$Fe_2(OH)_6$	Ferric hydrate.	
FeS	Ferrous sulphide.	
$FeSO_4$	" sulphate.	Green vitriol, copperas.
$Fe_2(SO_4)_3$	Ferric sulphate.	
$HC_2H_3O_2$	Hydrogen acetate.	Acetic acid.
H_2CO_3	" carbonate.	Carbonic acid.
HCl	" chloride.	Muriatic or chlorhydric acid.
$HClO$	" hypochlorite.	Hypochlorous acid.
HF	" fluoride.	Fluorhydric acid.
$HKSO_4$	" potassium sulphate.	Acid potassium sulphate.
HNO_3	" nitrate.	Nitric acid.
$HNaCO_3$	" sodium carbonate.	Bi-carbonate of soda.
HNa_2PO_4	" di-sodium phosphate.	Sodic phosphate.
$HNaSO_4$	" sodium sulphate.	Acid sodium sulphate.
H_2O	" oxide.	Water.
H_2S	" sulphide.	Sulphuretted hydrogen.
H_2SO_3	" sulphite.	Sulphurous acid.
H_2SO_4	" sulphate.	Sulphuric acid.
$H_2S_2O_7$	Fuming sulphuric acid.	Nordhausen sulphuric acid.
H_4SiO_4	Hydrogen silicate.	Silicic acid.
$HgCl$	Mercurous chloride.	Calomel.
$HgCl_2$	Mercuric chloride.	Corrosive sublimate.
$HgNO_3$	Mercurous nitrate.	
HgS	Mercuric sulphide.	Cinnabar.
$K_2Al_2(SO_4)_4$	Potassium aluminium sulphate.	Alum.
KBr	Potassium bromide.	Bromide of potash.
KCl	" chloride.	Chloride of potash.

$KClO_3$	Potassium chlorate.	Chlorate of potash.
KCN	" cyanide.	
$K_6Co_2(NO_2)_{12}$	" cobalt nitrate.	
K_2CrO_4	" chromate.	
$K_2Cr_2O_7$	" bi-chromate.	
$K_4Fe(CN)_6$	" ferro-cyanide.	Yellow prussiate of potash.
KI	" iodide.	
KNO_2	" nitrite.	
KNO_3	" nitrate.	Saltpetre, nitre.
K_2O	" oxide.	
KOH	" hydrate.	Caustic potash.
K_2SO_4	" sulphate.	
K_4SiO_4	" silicate.	Water glass, silicate of potassa.
$Mg_3(PO_4)_2$	Magnesium phosphate.	
$MgSO_4$	" sulphate.	Epsom salt.
MgO	" oxide.	Magnesia.
$MnCl_2$	Manganese chloride.	Muriate of manganese.
$Mn(OH)_2$	" hydrate.	
MnO_2	" dioxide.	Black oxide of manganese.
MnS	" sulphide.	
$MnSO_4$	" sulphate.	
$(NH_4)_2CO_3$	Ammonium carbonate.	
$(NH_4)_2C_2O_4$	" oxalate.	
NH_4MgAsO_4	" magnesium arsenate.	
NH_4Cl	" chloride.	Sal ammoniac, muriate of ammonia.
NH_4NO_3	" nitrate.	
NH_4OH	" hydrate.	Aqua ammonia.
$(NH_4)_2S$	" sulphide.	
$(NH_4)_2SO_4$	" sulphate.	
N_2O	Nitrogen protoxide.	Nitrous oxide, laughing gas.
NO or N_2O_2	" dioxide.	Nitric oxide.
NO_2 or N_2O_4	" tetroxide.	Nitrogen peroxide.
$NOCl$	Nitrosyl chloride.	Nitrogen oxychloride.
$NaCl$	Sodium chloride.	Common salt.
Na_2CO_3	" carbonate.	Carbonate of soda.
$NaNO_3$	" nitrate.	Chili saltpetre.
Na_2O	" oxide.	
$NaOH$	" hydrate.	Caustic soda, soda by lime.
Na_2SO_3	" sulphite.	
Na_2SO_4	" sulphate.	Glauber's salt.
$Na_2S_2O_3$	" thiosulphate.	Sodium hyposulphite, or hypo.
Na_4SiO_4	" silicate.	Water glass.

NiS	Nickel sulphide.	
$Ni(OH)_2$	" hydrate.	
P_2O_3	Phosphorus trioxide.	Phosphorous anhydride.
P_2O_5	" pentoxide.	Phosphoric anhydride.
$PbBr_2$	Lead bromide.	
$PbCl_2$	" chloride.	
$Pb(CN)_6$	" cyanide.	
$PbCO_3$	" carbonate.	White lead.
$Pb(C_2H_3O_2)_2$	" acetate.	Sugar of lead.
$PbCrO_4$	" chromate.	
$Pb_2Fe(CN)_6$	" ferro-cyanide.	
PbI_2	" iodide.	
$Pb(NO_3)_2$	" nitrate.	
PbO	" protoxide.	Litharge.
$Pb(OH)_2$	" hydrate.	
PbS	" sulphide.	Galenite, galena.
$PbSO_4$	" sulphate.	
SO_2	Sulphur dioxide.	Sulphurous anhydride, sulphurous acid.
Sb_2S_3	Antimony sulphide.	
$SbCl_3$	" chloride.	
$SbOCl$	" oxychloride.	
SiO_2	Silicon dioxide.	Silica, quartz, quartz sand.
SiF_4	" fluoride.	
$SrSO_4$	Strontium sulphate.	
$SrCO_3$	" carbonate.	
$SnCl_2$	Stannous chloride.	
$Sn_3(PO_4)_2$	" phosphate.	Phosphate of tin.
SnS	" sulphide.	Sulphide of tin.
SnS_2	Stannic sulphide.	
$Sn_2(SO_4)_3$	" sulphate.	
$ZnCl_2$	Zinc chloride.	
$Zn(NO_3)_2$	" nitrate.	
ZnS	" sulphide.	Sphalerite.
$ZnSO_4$	" sulphate.	White vitriol.

SOLUTIONS FOR REAGENTS AND ANALYSIS.

NUMBER OF GRAINS OF SOLIDS TO 500cc OF H_2O.

These solutions should be prepared (with distilled water preferably), filtered if necessary, and placed on shelves or a side-table for class use.

$AgNO_3$ 25	$K_2Al_2(SO_4)_4$.....50	Na_2CO_3.....50
$BaCl_2$.....50	KBr.....25	NaOH 60
$Ba(NO_3)_2$.....30	KCN 50	Na_2SO_3 100
$BiCl_3$.....50	K_2CrO_4 50	$Na_2S_2O_3$ .....sat.
$C_{12}H_{22}O_{11}$ .....sat.	$K_2Cr_2O_7$.....50	NH_4Cl 60
$CaCl_2$.....60	$K_4Fe(CN)_6$ 40	$(NH_4)_2C_2O_4$.....20
$Ca(OH)_2$ .....sat.	KI 25	NH_4NO_3 50
$CaSO_4$*.....sat.	KNO_2 50	$(NH_4)_2SO_4$.....50
$Co(NO_3)_2$ 50	KNO_3 50	$NiSO_4$.....50
$CuCl_2$.....50	KOH 60	$Pb(C_2H_3O_2)_2$.....50
$Cu(NO_3)_2$.....50	$MgCl_2$ 50	$Pb(NO_3)_2$.....100
$FeSO_4$* 50	$MgSO_4$ 50	$SnCl_2$†.....80
$HNaCO_3$.....50	$MnCl_2$ 50	$SrCl_2$.....50
HNa_2PO_4 50	Na_3AsO_3 60	$SbCl_3$.....50
$HgCl_2$ 30	NaCl 50	$ZnSO_4$.....50
$HgNO_3$ 25 + 25cc HNO_3		

$(NH_4)_2CO_3$ 100g, H_2O 400cc, NH_4OH 100cc.

$(NH_4)_2S$. Pass H_2S through 350cc NH_4OH till the sol. gives no ppt. with $MgSO_4$, and add 150cc H_2O.

Cochineal sol. is prepared by pulverizing 6g cochineal insects and covering for several days with a mixture of 400cc H_2O and 100cc alcohol, then filtering.

Litmus sol. is prepared by heating for several hours over a water-

* Prepare only as wanted. † Acidulate with HCl.

bath, 80g of pulverized litmus in 500cc of water, replacing the water as it evaporates, then filtering. Keep the sol. in an *open* bottle.

Indigo sol. (sulphindigotic acid) is made by slowly mixing and stirring 5g indigo with 25cc $H_2S_2O_7$ (fuming sulphuric acid) in a beaker immersed in cold water. Cover the beaker, and after 48 hours add 500cc H_2O; stir and filter.

Dilute acids are made by mixing one volume of the acid with four volumes of water NH_4OH should be diluted with three times its volume of water before using.

INDEX TO EXPERIMENTS.

1. LENGTH.

[*Read* RULES AND SUGGESTIONS.]

Ap.: metric ruler, 30^{cm} long, test-tube.

1. Note the length of 10^{cm} on a metric ruler.
2. Estimate by the eye alone this distance on the cover of a book.
3. Verify the result.
4. Estimate the same on a t.t., and verify.
5. Try with different objects till you carry in mind 10^{cm}.
6. Estimate the number of inches it covers, and verify.
7. In the same way experiment with 1^{cm}.
8. Measure the perpendicular distance between the blue lines of foolscap.
9. Measure the diameter of the *old* nickel five-cent piece.
10. Measure and estimate in the same way 5^{cm}.
11. Make a drawing of these measurements on the opposite page: one square decimeter, *i.e.* 10^{cm} on a side; 1^{qcm}.

2. VOLUME.

Ap.: graduate holding 25 or 50^{cc}.

1. Into a graduate put 10^{cc} of water, then pour it into a t.t.
2. Note, without marking, what proportion of the t.t. is filled. Make a drawing of it on the opposite page.
3. Pour out the water, then put into the t.t. the same quantity, estimating it by the eye alone.
4. Verify the result by pouring the water into the graduate.
5. Repeat this till you can estimate quite accurately.
6. Try it with a t.t. of another size.
7. Estimate 1^{cc} of a liquid in a similar way.
8. Estimate also 5^{cc}.
9. Draw figures of a graduating glass, and of a cube 1^{cm} on a side.

3. WEIGHT.

Ap.: pair of scales, 1, 5, 10^{g} weights.
Ch.: 50^{g} fine salt.

1. Balance a piece of paper on each pan of a pair of scales.
2. On one pan put a 10^{g} weight, and balance this with fine salt.
3. Note with the eye the quantity of salt, then remove it.
4. Now estimate the same quantity, and verify by weighing it.
5. Repeat the experiment several times.
6. Weigh 1^{g} and estimate as before.
7. See if 1^{g} can be piled on a one-cent coin.
8. Experiment with 5^{g} in a like way.
9. Make drawings of 1, 5, and 10^{g} weights.

4. THE MOLECULAR STATE.

Ap.: Bunsen burner (or alcohol lamp), two test-tubes, funnel, filter paper.

Ch.: 2^g sugar.

1. Put into a t.t. 2^g sugar, $C_{12}(H_2O)_{11}$, and cover it with 5^{cc} H_2O.
2. Boil it in a Bunsen flame for a minute, using the wooden test-tube holder, till the sugar disappears.
3. When cool, taste a drop of the liquid.
4. Arrange a filter paper and filter the liquid, catching the filtrate in another t.t.
5. Touch a drop of the filtrate to the tongue. Has the sugar gone through the filter paper?
6. Pour out half of the liquid, and save the rest for Exp. 5.
7. Take full notes of this experiment and all subsequent ones, describing what you do, what you see, and what you infer. Read the "Model for Taking Notes."

5. ELEMENTS AND THE ATOMIC STATE.

Ap.: test-tube.
Ch.: sugar solution, 3^{cc} sulphuric acid.

1. To the remainder of the sol., Exp. 4, slowly **add** an equal volume of H_2SO_4.
2. If the color is unchanged, add more.
3. Notice whether the temperature of the **t.t.** increases.
4. Observe any change of color, volume, and **state,** in the product.
5. Clean the t.t. with water.
6. Explain the phenomena.

6. CHEMICAL UNION.

Ap.: piece of ignition tubing (15^{cm} long, 1^{cm} diam.), lamp.
Ch. : 2^{g} brimstone, 1^{g} Cu turnings.

1. Mix well on paper 2^{g} S (brimstone, coarsely powdered) and the same *bulk* of Cu turnings, and put into a small i.t., made by drawing out a glass tube in the flame.
2. Hold the mixture in the flame till the substance becomes red hot throughout.
3. Break the tube with a jet of water and examine the contents. See whether they resemble either S or Cu.
4. Among the other notes write the equation for the chemical change, and explain it.

7. TO PREPARE APPARATUS.

Ap.: Lamp, round and triangular files, 3 pieces glass tubing (50^{cm} long), 2 corks.

1. Bore a small hole in a cork, either with a gimlet or with the pointed handle of a triangular file. Take care to have it perpendicular to the faces of the cork. With a round file enlarge the perforation, which must be perfectly circular, and a little smaller than the d.t. which it is to receive.
2. Heat in the upper flame a small glass tube, 15 or 20^{cm} long, one-third the distance from the end, holding each end between the first and second fingers and the thumb; rotate it from you with the thumb and forefinger of the right hand, holding it steadily in the flame till it yields; then, without twisting, bend it at right angles towards you. Make another bend a third of the distance from the other end; meantime rotate it, without twisting; while making this bend turn the glass so as to look lengthwise of it, and have the three parts lie in the same plane. If unsuccessful, try again with another tube.
3. Bend two d.t., each 40 or 50^{cm} long, as in the models, and fit them to perforated corks.

8. TO MAKE OXYGEN.

[*Read* RULES 2, 4, 5, 6.]

Ap.: r.s., lamp, p.t., t.t., d.t., 4 rec.
Ch.: 5^g $KClO_3$, 4^g MnO_2.

1. Mix 5^g KClO, with 3 or 4^g MnO_2. Do not pulverize the $KClO_3$.
2. Put the mixture into a large t.t., which should not be over half-full.
3. Adjust a stopper and d.t., and hang the apparatus on a r.s., having one end of the d.t. in a p.t.
4. Fill four wide-mouthed bottles with H_2O, and invert them on the shelf of the p.t., with water 1 or 2^{cm} above the shelf.
5. Put a flame against the t.t., holding the lamp and slowly moving it. Avoid heating too long in one place.
6. Catch the escaping gas in the inverted rec.
7. Remove the rec. when full, keeping them covered with glass plates.
8. Take out the end of the d.t. from the p.t., as soon as the lamp is removed, to prevent the water from drawing back.
9. Clean the t.t. by covering the residue with water, closing the mouth of the t.t. with the thumb, and shaking the contents vigorously, away from the table.
10. Notes and equation. $KClO_3 = ?$

9. TO BURN CARBON IN OXYGEN.

Ch.: rec. of O, splinter.

1. Put a burning stick into a rec. of O, and notice the combustion.
2. Remove, blow out the flame, and put in the stick again while red hot. Describe the result. Repeat this till there is no longer any effect.
3. Wood consists mostly of C and of H. $C + 2\,O = ?$ $2\,H + O = ?$

10. TO BURN SULPHUR IN OXYGEN.

Ap.: Cu wire, piece of crayon (3^{cm} long), lamp.
Ch.: rec. of O, piece of S (size of a pea).

1. Hollow out the end of a crayon or an electric-light pencil, and attach a Cu wire for a deflagrating spoon.
2. Put into it a bit of S, hold in the flame till the S burns, then lower it into a rec. of O. Notice the color and vigor of the flame.
3. When combustion ceases, remove the wire and cautiously take the odor. The gas is sulphur dioxide. $S + 2\,O = ?$

11. TO BURN PHOSPHORUS IN OXYGEN.

Ap.: forceps, def. sp. (wire and crayon), wire, lamp.
Ch. : piece of P (size of half a pea), rec. of O.

1. With the forceps put into a def. sp. a bit of P, half as large as a pea, after first drying it with paper.
2. Heat one end of a wire or some metal, touch the P with it, and lower the P at once into a rec. of O.
3. When combustion ceases, remove and burn every bit of the P by holding it in a flame.
4. Describe the flame and the product. $2P+5O=?$ $2P+3O=?$

12. TO BURN IRON IN OXYGEN.

Ap.: lamp, e.d.
Ch.: rec. of O, little S, picture-cord wire (10^{cm} long).

1. With forceps hold one end of a picture-cord wire, or a steel shaving, 5 or 10^{cm} long, in a flame for an instant, then dip it into a bit of powdered S.
2. Hold it again in the flame till the S burns, then put it into a rec. of O, with a little H_2O in the bottom.
3. If the Fe does not burn, repeat with another rec. Have but little S on the wire. $3\,Fe + 4\,O = ?$

13. TO SEPARATE NITROGEN.

Ap.: e.d., p.t., def. sp., rec. and glass, forceps, wire, lamp.
Ch.: piece of P (half the size of a pea).

1. Fill a p.t. with water to 1 or 2^{cm} above the shelf.
2. Prepare a def. sp. with the wire bent sharply 5 or 6^{cm} from the bowl of the spoon.
3. Pass the wire through the orifice in the shelf of the p.t., fasten it there, and invert a rec. or small graduate over it, so as to seal the mouth under water. When easily adjustable, remove the rec., leaving the wire.
4. Using forceps and e.d., dry a piece of P (size of half a pea) on paper, and put it into the spoon.
5. Touch it with a hot wire or the handle of a file, and instantly invert the rec. over it as before. Hold the rec. steadily with the hand till combustion ceases.
6. Before removing the def. sp. be sure that combustion has stopped, and let no air enter. $2P+5O=?$ $2P+3O=?$
7. Finally remove the spoon, without admitting air or disturbing the rec.
8. Burn the P and leave the rec. till the gas becomes tolerably clear; then remove it with a glass plate, leaving the water in the bottom.

14. PROPERTIES OF NITROGEN AND COMPOSITION OF AIR.

Ap.: graduate.
Ch.: rec. of N, splinter, match.

1. Put a burning stick into the N, sliding along the glass plate enough to admit it. Note the effect. Try this with a glowing stick.
2. See whether the P and S on the end of a match will burn in the gas.
3. Why is there no equation for this experiment?
4. To find the proportion of O to N in air, prepare a rec. of N, and, before removing it, sink the inverted rec. into the p.t. till the water is at the same height both inside and outside, then slip the glass plate under it and remove.
5. Measure the water accurately by pouring it into a graduate. Then measure the total capacity of the rec. in the same way, and compute the percentage of O (by volume) in the air, remembering that the volume of water represents the volume of O burned.

15. TO MAKE HYDROGEN.

Ap.: p.t., 4 rec., t.t., d.t., r.s.
Ch.: 5^g Zn., 15^{cc} HCl.

1. Prepare apparatus as for making O.
2. Into a t.t. put 5^g granulated Zn, 5^{cc} H_2O and 5^{cc} HCl.
3. Have the bearings perfectly tight, and collect the gas like O. No heat need be applied.
4. If the action ceases, add more HCl. Reaction.
5. Invariably keep the rec. of H inverted on a glass plate on removing them.

16. COMBUSTION OF HYDROGEN.

Ap.: lamp, glass tube (10^{cm} long, $\frac{1}{2}^{cm}$ diam.), glass tube (50^{cm} long, 2 or 3^{cm} diam.), t.t., H gen., rec.
Ch.: rec. H, stick.

1. Lift an inverted rec. of H, and hold it in the same position over a flame, watching the result. Reaction.
2. Insert a burning stick into an inverted rec. of H. Note the effect on the stick and on the H.
3. Make a philosopher's lamp with a H gen., drawing out a glass tube for this purpose. Before lighting it, test the purity of the H, by exploding a test-tube full in the flame. When no sharp report ensues, light the flame; avoid pointing the tube towards any one. Reaction.
4. When it burns, lower a large glass tube (2 or 3^{cm} in diam.) over the flame.
5. Hold a *dry* bottle over the flame for some time and look for moisture on the sides.
6. Collect by up. disp. a dry t.t. of H, explode it over a flame, and look for any product.
7. Wash and return any Zn that is not used.

17. EXPLOSION OF HYDROGEN.

Ap.: soda-bottle, p.t., t.t., d.t., r.s., lamp.
Ch.: 2^{g} Zn, 5^{cc} HCl.

1. Fill a soda-bottle with water, invert it in a p.t., and fill it not over one-fifth full of H.
2. Lift the bottle, inverted, to let the water run out and air take its place.
3. Cover the mouth of the bottle with the hand, and shake well, so as to mix the H and the air.
4. Now bring its mouth to a flame.

18. TO MAKE CHARCOAL.

Ap.: lamp, r.s., small Hessian crucible, sand, e.d.
Ch.: pieces of wood about 2^{cm} long or square.

1. Put 2 or 3 small and thin pieces of wood into a small Hessian crucible, and cover them with sand.
2. Apply a strong heat for half an hour, or until gases cease to come off, then let it cool; pour off the sand (save it), and examine the wood. Notice any gases rising during the experiment. Explain.
3. Hold a piece of the charcoal in a Bunsen flame. See whether it burns with flame or only glows.
4. Hold an e.d. in the flame of a Bunsen burner, having the basal orifices closed. As gas consists mainly of compounds of H and C, explain the effect.
5. Open the orifices, and try to burn off some of the deposited C.

19. DISINFECTING ACTION OF CHARCOAL.

Ap.: t.t., 2 rec., funnel, filter paper.
Ch.: 2^g FeS, 5^{cc} HCl, 5^g charcoal.

1. Prepare a sol. of H_2S (Exp. 73) in a rec. with 20^{cc} H_2O. Notice the odor.
2. Put into the rec. 5^g powdered charcoal, and shake the mixture well.
3. Pour the whole on a filter, collect the filtrate in a clean rec., and see whether any odor remains. If so, use more coal and filter again.

20. DECOLORIZING ACTION OF CHARCOAL.

Ap. : t.t., 2 rec., funnel, filter paper.
Ch. : 5^{g} bone black, 20^{cc} cochineal sol.

1. Put into a rec. 5^{g} of bone-black, and add 20^{cc} cochineal sol.
2. Shake well, then filter into a clean rec., and notice the color of the liquid. If not perfectly colorless, filter again with the same material, or add more C.

21. CONDENSING ACTION OF CHARCOAL.

Ap.: paper.
Ch.: 3ᵍ bone-black, P (half the size of a pea).

1. Dry a piece of P, and put it on paper 3 or 4 folds in thickness.
2. Cover it with 3ᵍ of powdered bone-black, and leave it in a warm place till combustion ensues. Explain and give equation.
3. Finally burn all the P.

22. REDUCING ACTION OF CARBON.

Ap.: lamp, i.t., e.d.
Ch.: 5^g CuO, $\frac{1}{2}^g$ charcoal (powdered), 3^{cc} HNO_3.

1. Put into a prepared i.t. (10^{cm} long, $\frac{1}{2}^{cm}$ diam.), 5^g of a mixture of CuO and powdered charcoal (10 pts. CuO to 1 pt. C by weight). The tube should not be over $\frac{1}{3}$ full.
2. Heat to redness for 5 or 10 minutes.
3. Cool and notice whether the volume has diminished.
4. Remove the contents to a paper and look for metallic Cu. $2\,CuO + C = ?$ $CuO + C = ?$
5. Test it by putting some into an e.d. and adding 2 or 3^{cc} HNO_3. Observe the color of the fumes and of the liquid. $3\,Cu + 8\,HNO_3 = 3\,Cu(NO_3)_2 + 4\,H_2O + ?$

23. SOLUTION AND DEPOSITION OF SILVER.

Ap.: e.d., lamp, r.s., plate.
Ch.: a dime, a cent or a Cu wire, 5^{cc} HNO_2.

1. Put a ten-cent Ag coin or other piece of Ag into an e.d. and pour over it from a t.t. a mixture of 5^{cc} HNO_3 and 10^{cc} H_2O.
2. *Warm* till all or nearly all the Ag dissolves; then remove the lamp and let the liquid cool. Take out any Ag that is left. $3\,Ag + 4\,HNO_3 = ?$
3. Then add 10^{cc} H_2O, and at once put into it a one-cent coin or a Cu wire.
4. Leave this till quite a deposit appears, then pour off the liquid, *wash the deposit thoroughly*, and remove it from the coin. $2\,AgNO_3 + Cu = ?$
5. Examine to see what the metal is, and save it.

24. SOLUTION AND DEPOSITION OF COPPER.

Ap.: e.d., r.s., lamp, plate.
Ch.: a cent or 2^g Cu, a strip of Pb, 5^{cc} HNO_3.

1. Dissolve a Cu cent or some Cu turnings in a mixture of 5^{cc} $HNO_3 + 10^{cc}$ H_2O. Warm till the metal has nearly dissolved; then cool, remove the remainder (as in Exp. 23), add 10^{cc} H_2O, and put in a piece of Pb about the same size as the Cu used.
2. Examine the deposit, and explain fully.
   $3\,Cu + 8\,HNO_3 = ?$
   $Cu\,(NO_3)_2 + Pb = ?$

25. SOLUTION AND DEPOSITION OF LEAD.

Ap.: e.d., r.s., lamp, plate.
Ch.: a piece of Pb, a piece of Zn, 5^{cc} HNO_3.

1. Do this experiment like the two previous, dissolving a piece of Pb, not larger than a cent in 5^{cc} HNO_3 and 10^{cc} H_2O; warm till the Pb has nearly dissolved, cool, remove any extra Pb, add 10^{cc} water and a piece of Zn the size of the Pb used.
2. Examine the deposit and identify it. $3\,Pb + 8\,HNO_3 = ?$ $Pb\,(NO_3)_2 + Zn = ?$
3. State what is shown by Exps. 23, 24, 25 of the electro-positive and electro-negative relation of Ag, Cu, Pb, and Zn.

26. WHAT ACIDS ARE.

Ap.: e.d., stirring rod.

Ch.: HCl, HNO_3, H_2SO_4 (a few drops each), litmus paper (small strips).

1. Pour into an e.d. a few drops HCl, add 5^{cc} H_2O, stir it, and taste a drop from the st.r.
2. Dip the end of a strip of blue litmus paper into it; notice the effect.
3. Wash the e.d. well, then put in a few drops of HNO_3 and 5^{cc} H_2O and stir.
4. Notice the taste of this, and its action on blue litmus, as before.
5. Prepare and test similarly H_2SO_4.
6. State your conclusions as to the action and the composition of acids, and frame a definition. Observe in this connection the common element in the three acids, and whether the rest of the symbol is negative or positive.

27. WHAT BASES ARE.

Ap. : e.d., st.r.

Ch. : NH_4OH, NaOH, KOH (a few drops each), HCl, litmus paper (strips).

1. Pour into an e.d. a few drops of NH_4OH, add 5^{cc} H_2O, stir it, and taste a drop.
2. Dip the end of a strip of *red* litmus paper into it. To redden blue litmus hold it in the *fumes* of HCl. To change red litmus to blue, hold it in the *fumes* of NH_4OH. One piece of litmus paper can thus be used repeatedly.
3. Wash the e.d. and prepare and test NaOH sol. in the same way.
4. Do the same with KOH sol.
5. State your conclusions regarding the action and the composition of bases. Observe the two common elements in the three bases, and whether the rest of the symbol is negative or positive. Give a definition.

28. ACID AND ALKALINE REACTIONS.

Ap.: beaker, st.r., e.d.
Ch.: 5^{cc} lit. sol., HCl, HNO_3, H_2SO_4, NH_4OH, KOH sol. NaOH sol. (a few drops each).

1. Pour into a small beaker or a t.t. 5^{cc} of an aqueous solution of blue litmus.
2. Pour a few drops of HCl into an e.d., and dip a st.r. into this, then stir the lit. sol. with it, noticing any change of color. If there is no change, add another drop with the rod. This shows an acid reaction.
3. Pour a few drops of NH_4OH into a clean e.d., dip the st.r. into it, then stir the lit. sol. with it. If the color is unchanged, repeat till blue is again obtained. This shows an alkaline reaction.
4. In the same way put a drop — or more if needed — of HNO_3 from an e.d. into the same blue sol. When it is reddened, add a drop or more of NaOH sol., till it becomes blue.
5. Change it again to red with a drop of H_2SO_4, and restore the color with KOH sol.

29. WHAT SALTS ARE.

Ap.: e.d.

Ch.: sol. of NaCl, KNO_3, $(NH_4)_2SO_4$, Na_2CO_3, $HNaCO_3$ (2^{cc} each), litmus.

1. Pour into a clean e.d. 1 or 2^{cc} of NaCl sol. in water, taste a drop of it, and test it with litmus.
2. Test in the same way 1 or 2^{cc} of KNO_3 sol.
3. Test similarly as sol. of $(NH_4)_2\,SO_4$.
4. State your conclusions as to the usual action of salts, and as to their composition.
5. Test, however, a sol. of Na_2CO_3.
6. Test, also, a sol. of $HNaCO_3$.
7. From the strength of the acid and that of the base which the last two salts represent, account for the phenomena.

30. TO MAKE SODIUM CHLORIDE.

Ap.: r.s., lamp, plate, asbestus, e.d., st.r., 2 t.t., beaker.
Ch.: 5^{cc} sol. NaOH, 5^{cc} HCl, litmus.

1. Measure in a t.t. 5^{cc} NaOH sol. and pour it into an e.d.
2. Pour into a clean t.t. 4 or 5^{cc} HCl, and add some of this, a little at a time, to the NaOH sol., stirring it meantime, till the product is neutral to litmus paper. When nearly neutral, add a drop at a time with the st.r. Test with both colors. Turn the paper from one color to the other as directed in Exp. 27. Use only the end of the paper, putting it on the side of the e.d. If blue litmus paper is reddened, add NaOH sol., a drop at a time. If red litmus is turned blue, add a drop of HCl.
3. When no effect is produced on either red or blue litmus after leaving for a minute, evaporate the liquid to dryness by boiling it over a plate and asbestus paper.
4. When cool, examine the residue and taste it. Reaction. What is the object of evaporation?

31. TO MAKE POTASSIUM SULPHATE.

Ap.: same as in last experiment.
Ch.: 5^{cc} KOH sol., 5^{cc} H_2SO_4, litmus.

1. Into an e.d. put 5^{cc} KOH sol.
2. Neutralize it with H_2SO_4 from a t.t., as in the previous experiment.
3. When it is absolutely neutral, evaporate the water.
4. Taste the product. Give the equation.

32. TO MAKE AMMONIUM NITRATE.

Ap.: same as in previous experiment.
Ch.: 5^{cc} NH_4OH, 5^{cc} HNO_3, litmus.

1. Put into an e.d. 5^{cc} NH_4OH.
2. Neutralize this with HNO_3 from a t.t. or beaker, as in the previous experiment.
3. Evaporate till white fumes begin to appear.
4. Cool, and taste the residue. Reaction.
5. After writing up this experiment, write reactions for the union of: (1) NaOH and HNO_3, (2) NaOH and H_2SO_4, (3) KOH and HNO_3, (4) KOH and HCl, (5) NH_4OH and HCl, (6) NH_4OH and H_2SO_4. Use a separate line for each. State a method of preparing salts.

33. TO MAKE CHLORHYDRIC ACID.

Two pupils may work together.

[*Read* RULE 11.]

Ap.: r.s., lamp, plate, asbestus, flask, d.t., rec. (for Wolff bottles).

Ch.: 10^g NaCl, 20^{cc} H_2SO_4, 2^{cc} NH_4OH.

1. Into a flask put 10^g NaCl and 20^{cc} H_2SO_4. Be sure to have enough acid, or the flask will crack.
2. Fill two or more rec. one-quarter full of water.
3. Connect the apparatus as in the model, observing how the tubes extend, and having one ring above the flask to hold it.
4. Heat slowly 15 minutes over asbestus. Do not let the frothing extend to the neck of the flask. Reaction. Look for any current in the liquid of the rec. On detaching the apparatus, pass a little of the gas over some NH_4OH in an e.d. Notice the fumes, and write the equation.
5. Let the flask stand till cool, then clean it with water.

34. TESTS FOR CHLORHYDRIC ACID.

Ap.: t.t., e.d.

Ch.: lit., rec. HCl, bit of Zn, 2cc $Pb(NO_3)_2$ sol., 2cc $AgNO_3$ sol., 2cc $HgNO_3$ sol.

1. Test the liquid in each rec. with lit., and taste a drop.
2. Pour 10cc from the *first rec.* into a t.t., and add a piece of Zn. Reaction. Ignite the escaping gas.
3. Put into a t.t. 2cc $AgNO_3$ sol., and add 2cc of the liquid from the first rec. Reaction. What is the ppt.?
4. Put into a t.t. 2cc $Pb(NO_3)_2$ sol., and add 2cc of the liquid from the first rec. Reaction. Name the ppt.
5. Put into a t.t. 2cc $HgNO_3$ sol., and add 2cc of the liquid from the first rec. Name the ppt. Reaction.

35. FLUORHYDRIC ACID AND ETCHING.

Ap.: lead tray (5 or 6^{cm} square 1^{cm} deep), r.s., lamp, plate, glass.

Ch.: 2^{g} CaF_2, 4^{cc} H_2SO_4, piece of beeswax.

1. Cover thinly with beeswax one side of a small piece of glass. Spread the wax evenly over the surface by warming the other side of the glass.
2. With a sharp metallic point mark some design through the wax when it is hard.
3. Put into a lead tray 2^{g} powdered CaF_2, cover it with H_2SO_4, and mix.
4. Lay the glass, wax side down, over the tray, and put this *high above a small flame*, so as to *warm* the contents and not melt the wax.
5. After 5 or 10 minutes remove the lamp, and leave the tray and glass in a warm place for at least half an hour; two hours would be better. Avoid inhaling the gas. $CaF_2 + H_2SO_4 = ?$
6. Remove the wax, clean the glass with a cloth wet with benzine or naphtha, and look for the design. $4\,HF + SiO_2 = ?$

36. TO MAKE NITRIC ACID.

Ap.: r.s., lamp, plate, asbestus, flask, d.t., t.t., rec.
Ch.: 5^g $NaNO_3$ (or KNO_3), 10^{cc} H_2SO_4.

1. Put into a flask or large t.t. 5^g $NaNO_3$ (or KNO_3) and 10^{cc} H_2SO_4.
2. Attach a d.t. and fit a cork tightly.
3. Put the other end of the d.t. into a t.t., and sink this to the bottom of a rec. of water.
4. Heat the flask on a r.s. over asbestus, and collect 4 or 5^{cc} of the liquid. Take care that none of the salt passes over. If a t.t. is used, put the flame against the upper part of the liquid. Avoid having the liquid draw back by removing the t.t. as soon as the heat is taken away.
5. Note the color of the acid, and account for it. Equation.

37. TESTS FOR NITRIC ACID.

Ap.: t.t., e.d.

Ch.: lit., a bit of white silk (or quill), $\frac{1}{2}^{g}$ Cu turnings, 1^{cc} cochineal sol., 1^{g} charcoal, 5^{cc} HNO_3.

1. Test with lit. the liquid prepared in the last experiment.
2. Put a drop on the finger with a st.r., and wash it off at once. Note any color.
3. Dip a quill or piece of white silk into it for an instant, then wash it, noticing the color.
4. Add a little to a few bits of Cu turnings in an e.d. Reaction. See Exp. 22.
5. To 1^{cc} indigo solution add 1^{cc} HNO_3. Result.
6. Heat in an e.d. 1^{g} fine charcoal, and then add 1^{cc} HNO_3.

2, 3, 4, 6 are characteristic tests.

38. NITRO-HYDROCHLORIC ACID.

Ap.: 2 t.t.
Ch.: 2^{qcm} Au leaf, 6^{cc} HCl, 2^{cc} HNO_3.

1. Put into each of 2 t.t. 1^{qcm} of gold leaf.
2. To one add 6^{cc} HCl, to the other 2^{cc} HNO_3. If the gold does not disappear from either, boil each for an instant.
3. Pour the two acids together, and observe.
   $3\,HCl + HNO_3 = NOCl + 2\,H_2O + ?$ $Au + 3\,Cl = ?$

39. SULPHUROUS ACID.

Ap.: lamp, 2 t.t., d.t.
Ch.: lit., 3^{g} Cu, 4^{cc} H_2SO_4.

1. To 2 or 3^{g} Cu turnings in a t.t. add 3 or 4^{cc} H_2SO_4.
2. Attach a d.t. that leads into an open t.t., in which are 5 or 10^{cc} H_2O, and attach to a r.s. Heat the t.t. containing the reagents and let the gas bubble, for 2 or 3 minutes, through the water. Cautiously take the odor.
3. Reactions for the liberation of SO_2, and for its combination with H_2O.
4. What is another mode of making H_2SO_3?

40. TO MAKE SULPHURIC ACID.

Two pupils may work together.

Ap.: 1 rec., 3 t.t., 3 d.t., 2 lamps, r.s.
Ch.: 10^{g} Cu turnings, 5^{cc} H_2SO_4, 5^{cc} HNO_3.

1. Fit a rec. or a large t.t. with a cork which has 4 perforations, 3 of which are to be connected by a d.t. to 3 other t.t., the fourth to be left open. Fit the stopper loosely to the rec.
2. Into one t.t. put 10^{cc} H_2O; into another 5^{g} Cu and 5^{cc} H_2SO_4; into the third 5^{g} Cu, 5^{cc} H_2O, 5^{cc} HNO_3.
3. Connect each t.t. with the rec. by a d.t. Put the rec. on an iron plate on the r.s., and heat the tubes containing H_2O and H_2SO_4, also the other if necessary. Collect a little liquid in the rec. Avoid forcing over any liquid. If any goes over from the H_2SO_4 or the HNO_3 tube, clean out the rec. and begin again.
4. Give the equation for the reaction in each t.t. and in the rec. Make a diagram of the ap.

41. TESTS FOR SULPHURIC ACID.

Ap.: t.t.

Ch.: lit., $BaCl_2$ sol. (few drops), H_2SO_4 (from previous experiment, also from reagent bottle), 2^{cc} sugar sol., splinter, starch (fragment).

1. Test with lit. the liquid generated in the previous experiment.
2. To some of the liquid poured into a t.t. add a few drops of clear $BaCl_2$ sol., and look for a ppt. This is a test for H_2SO_4, and for the soluble sulphates. Give the reaction and name the product.
3. Put one drop H_2SO_4 (from reagent bottle) into a clean t.t., add 10^{cc} H_2O, shake, add one drop $BaCl_2$ sol., and look for a ppt.
4. Put one drop of strong H_2SO_4, and one from that just made, on writing-paper, and evaporate them high over a flame, so as not to burn the paper. When dry, examine.
5. Put 2^{cc} of strong H_2SO_4 into a t.t. and dip into it a splinter. Wood and paper are mostly cellulose, $C_{18}(H_2O)_{15}$. Explain the charring.
6. To 2^{cc} sugar sol., $C_{12}(H_2O)_{11}$, add 2^{cc} H_2SO_4, and explain.
7. Cover a fragment of starch, $C_6(H_2O)_5$, with H_2SO_4 in a t.t.; boil till it begins to blacken. Explain.

42. ACTION OF SULPHURIC ACID ON WATER.

Ap.: small t.t., also large one, e.d., graduate, 2 rec.
Ch.: 2^{cc} NH_4OH, 25^{cc} H_2SO_4.

1. Into a very small t.t. put 2^{cc} NH_4OH.
2. Pour into an e.d. or a beaker 5^{cc} H_2O, and into this pour slowly 15^{cc} H_2SO_4. Use the small t.t. containing the NH_4OH for a st.r., while mixing them, and look for any ebullition. Observe, with a chemical thermometer, the temperature of the water before mixing, then of the mixture. Notice the heat of the e.d. and of the t.t.
3. Measure in a graduate exactly 10^{cc} H_2SO_4 and pour it into a rec. or beaker. Set this aside till the next lab. hour, putting into another open rec. near by, twice as much water or more. Mark the one having H_2SO_4.
4. At the next hour (next week) measure accurately the volume of H_2SO_4. Save the acid.

43. TO MAKE AMMONIUM HYDRATE.

[*Read* RULE 11.]

In this experiment two pupils may work together.

Ap.: mortar, flask, 2 (or more) rec. (for Wolff bottles), d.t., e.d., lamp, r.s., plate, and asbestus.
Ch.: 10^g NH_4Cl, 10^g $Ca(OH)_2$, 2^{cc} HCl, lit., 5^{cc} $FeSO_4$ sol.

1. Powder and put into a flask 10^g NH_4Cl and 10^g freshly slaked $Ca(OH)_2$.
2. Add 25^{cc} H_2O, and connect with Wolff bottles containing water, as in making HCl. Have the tubes as in the model.
3. Heat 10 minutes, using a plate and asbestus paper. Reaction.
4. Disconnect the flask, put 2^{cc} HCl into an e.d., and pass the gas over it from the gen. Observe the fumes, and give the reaction for them. This is the test for ammonia. Let the flask cool as it stands, and test the liquid in the rec. with red lit.
5. Put 5^{cc} $FeSO_4$ sol. into a t.t., and pour in 2 or 3^{cc} of the prepared NH_4OH. Note effect and color, and write reaction. Name the ppt.

44. AMMONIA.

Ap.: mortar, lamp, t.t.
Ch.: 5^g NH_4NO_3, 5^g $Ca(OH)_2$, lit.

1. Pulverize 5^g NH_4NO_3 in a clean mortar.
2. Mix with it 5^g fine $Ca(OH)_2$.
3. Put them into a t.t., and warm it. Equation.
4. Test the gas by holding lit. at the open end of the tube while heating it. Test it also with HCl. Equation. Notice the odor.

45. AMMONIA.

Ap.: lamp, t.t.
Ch.: 5^g NH_4Cl (or NH_4NO_3), 5^{cc} NaOH (or KOH) sol., lit.

1. Put into a t.t. 5^g NH_4Cl (or NH_4NO_3), and add 5^{cc} NaOH (or KOH) sol.
2. Warm it and apply the same tests as before. Equation.

46. TO MAKE POTASSIUM HYDRATE.

Ap.: rec., paper.
Ch.: K (half size of pea), lit.

1. Put 20^{cc} H_2O into a clean rec.
2. Take from the naphtha in which it is kept a piece of metallic K, using forceps and e.d.; drop it into the rec., and at once cover this loosely with paper. Note the color of the flame and the activity of the combustion.
3. When action ceases, test the liquid with red litmus, and draw an inference as to the class of compounds to which it belongs.
4. What is the color, and what the lustre of freshly cut K; also its sp. gr. as compared with water?
5. Write equations for (1) the union of K and H_2O, (2) the combustion of H, (3) the combustion of K.

47. TO MAKE SODIUM HYDRATE.

Ap.: rec., paper.
Ch.: Na (half size of pea), lit.

1. Put into a clean rec. 20^{cc} H_2O.
2. Drop into this a piece of metallic Na, and cover the rec. as in Exp. 46. Compare the color and the lustre of freshly cut Na, and its chemical activity with those of K. Equation.
3. Test the liquid with red lit., and draw inference.
4. Heat 10^{cc} H_2O in a t.t. and pour it into a rec. Drop into the hot water a piece of Na, and cover the rec. with paper. Do not watch it at too close a range. Why was it more active than before?

48. TO MAKE SODIUM HYDRATE.

Ap.: e.d., lamp, r.s., plate, lit.
Ch.: 5^g Na_2CO_3, 2^g $Ca(OH)_2$.

1. Dissolve 5^g crystals of Na_2CO_3 in 20^{cc} H_2O, and heat just below boiling in an e.d.
2. Then add a mixture of 2^g $Ca(OH)_2$ in 8^{cc} H_2O.
3. Boil five minutes. Cool, and pour off the liquid or filter it. Test with lit. $Na_2CO_3 + Ca(OH)_2 = ?$
4. What is the insoluble residue? By evap. the NaOH can be obtained as a solid.
5. Write equation for making KOH similarly.

49. TO MAKE NITROGEN PROTOXIDE.

In this experiment two pupils may work together.

Ap.: r.s., lamp, flask, 2 d.t., 3 rec., large t.t., p.t.
Ch.: 10^g NH_4NO_3, lit.

1. Put into a flask (of 200^{cc}) 10^g NH_4NO_3.
2. Connect the flask with a large t.t. or rec., resting in a rec. of H_2O, and from this t.t. have a d.t. leading to a p.t., so as to collect the gas over water. Have the bearings tight.
3. Heat not too rapidly. Obtain 2 rec. of gas, then remove the lamp and take the d.t. from the water. Cool the flask on the r.s. Equation.
4. Taste *a drop* of the liquid in the large t.t., and test it with red and blue lit. Some NH_4NO_3 will probably have been driven over.

50. COMBUSTION IN NITROGEN PROTOXIDE.

Ch.: rec. N_2O (2 or more), stick, S, P (small bit of each).

1. Try a burning stick in a rec. of N_2O, also a red-hot one.
2. Try the combustibility of S or of P, or both, in N_2O. Have the S burning briskly.

51. TO MAKE NITROGEN DIOXIDE.

Ap.: r.s., t.t., d.t., p.t., 2 rec.
Ch.: 5^g Cu turnings (fine), 10^{cc} HNO_3.

1. Put into a t.t. 5^g Cu turnings, 5^{cc} H_2O, 5^{cc} HNO_3.
2. Arrange the apparatus as in the H experiment, and collect the gas (2 rec.) over water.
3. If necessary, add more of reagents (Cu, H_2O, HNO_3), and moderate heat may be applied. Equation. [Exp. 22.]

52. COMBUSTION IN NITROGEN DIOXIDE.

Ap.: def. sp.
Ch. : splinter, S, P (same size as usual).

1. Try a burning stick in NO. Also, with the same rec., try burning S in a def. sp. or on a wire.
2. Try P when *well burning*. Admit as little air as possible. If it burns, give the equation.
3. Finally burn all the P as usual.

53. NITROGEN TETROXIDE.

Ap.: t.t., lamp.
Ch.: rec. NO, 1^{g} $Pb(NO_3)_2$, 1^{g} starch, 1^{cc} HNO_3, splinter.

1. Lift a rec. of NO from the p.t. Reaction.
2. Heat 1^{g} of powdered $Pb(NO_3)_2$ in a t.t. $Pb(NO_3)_2 = PbO + 2\,NO_2 + ?$
3. To 1^{g} of starch in a t.t. add 1^{cc} HNO_3, and heat a moment.
4. Put a burning stick into the gas. Is the latter a supporter of combustion?

54. CARBON DIOXIDE.

Ap.: 2 t.t., d.t., rec., lamp, glass tube.
Ch.: 5^g $CaCO_3$, 10^{cc} HCl, 5^{cc} $Ca(OH)_2$ sol., candle.

1. Put 5^g $CaCO_3$ (marble in lumps) or Na_2CO_3 into a t.t., or a rec.; add 5^{cc} H_2O, and 5^{cc} HCl. Add more of the reagents as needed. Enough must be used to produce vigorous action. Equation.
2. Test the gas with a burning stick.
3. Attach a d.t. and collect one rec. of gas by down. disp., covering the rec. loosely with paper.
4. Pour a rec. of the gas down over a burning stick or candle, and note result.
5. Let the gas bubble from a d.t. into 5^{cc} $Ca(OH)_2$ sol. in another t.t. Look for a ppt. Equation. Let the action continue till the liquid clears. There is now excess of CO_2. $CO_2 + H_2O = ?$
6. When the sol. is clear, boil for a minute, and notice the reappearance of the ppt. $H_2CO_3 - CO_2 = ?$
7. Explain the phenomena.
8. Take 2^{cc} $Ca(OH)_2$ sol. in a clean t.t., and blow into it through a glass tube. What does the result show?
9. Put a little $Ca(OH)_2$ sol. in an e.d., and look for a scum after a few minutes. Explain.

55. STRUCTURE OF FLAME.

Ap.: lamp.
Ch.: candle.

1. Examine the structure of a Bunsen burner (unscrew the top), make a drawing to show the orifices, and state what use each subserves. Light the gas at the base for a minute.
2. Replace the top, and light the gas at the top of the burner.
3. Hold the flame in front of a dark object, examine the parts, make a drawing, give a brief description, and state the color of each part.
4. Put the flame in direct sunlight, and study the parts from its shadow, to confirm your results.
5. Make a careful examination of the parts and colors of a candle flame, and make a drawing to show them. Move it slightly in the air to show the outer flame. This is best seen in a dark room.

56. COMBUSTION OF FLAME.

Ap.: lamp, small d.t., Pt wire.
Ch.: stick, paper, wire gauze.

1. Light the gas of a Bunsen burner.
2. Put a stick across the base of the flame for an instant, and notice what parts are burned. Make a sketch.
3. Hold a stick just above the inner blue cone of the flame.
4. Press quickly down on the flame with a paper, remove before it burns, and notice the shape of the charred part. Sketch. Press down on the flame with a fine wire gauze, and observe by the glowing of the wire where the heat is most intense.
5. Test the heat of the *inner cone* with the end of a Pt wire. Notice that it glows when near the top, but not elsewhere in this cone.
6. Put one end of a small d.t. into the inner blue cone, and try to light the gas at the other end.
7. From the above state what takes place in each of the two chief parts of the flame.

57. LIGHT OF FLAME.

Ap.: lamp, e.d.
Ch.: $\frac{1}{4}^{g}$ fine charcoal.

1. Observe the light of a Bunsen flame, and its color.
2. Sprinkle a very little charcoal-dust in the flame, and note any change of light or color.
3. Close the orifices at the base of the burner, and explain the change of light.
4. Hold an e.d. in the upper part of this closed flame for a minute, and notice deposit.
5. Now open the orifices and persistently try to burn off a little of the deposit from the e.d.
6. What is the cause of light in a flame?

58. TO CONFINE FLAME.

Ap.: lamp, 2 pieces wire gauze (10^{cm} square).

1. Light the gas and hold a fine wire gauze 3 or 4^{cm} above the burner. Why does it not burn above the wire?
2. Extinguish, then relight the gas above the gauze. Result.
3. Gradually lift the wire till the gas will not burn.
4. Again light the gas above the gauze, and hold another gauze above the flame, so as to confine it above and below.
5. From this experiment define *kindling point*, and state three conditions of combustion.

59. OXIDIZING AND REDUCING FLAMES.

Ap.: charcoal, blow-pipe, lamp.
Ch.: Pb (small bit); ½ g PbO.

1. Put a fragment of Pb, not larger than a pea, on a piece of charcoal, slightly hollowed out to hold it.
2. Insert the metallic tube in a Bunsen burner, and with a mouth blow-pipe blow the *oxidizing flame* strongly and steadily against the Pb for 4 or 5 minutes.
3. As you stop blowing, notice the yellow vapor that escapes from the pellet of Pb; also, as it cools, the yellow coating of PbO on the coal. Reaction.
4. Put ½ g PbO on a piece of charcoal. With the blow-pipe blow the *reducing flame* steadily against it for some time, or until a metallic pellet is obtained. What is it? Equation.
5. Extinguish the fire, if the coal still glows, by a jet of water.

60. TO MAKE CHLORINE.

Ap.: 2 rec., t.t., paper.
Ch.: 5^g MnO_2, 10^{cc} HCl.

1. Put into a t.t. 5^g MnO_2 and 10^{cc} HCl. Shake the mixture well.
2. Collect the gas by down. disp. in rec. loosely covered with paper. Apply heat gently, and avoid inhaling the gas.
3. Note the color of the gas, and its sp. gr. as compared with air. Observe when the rec. is filled, to avoid passing the gas into the room. If, accidentally, you breathe any Cl, inhale the vapor of alcohol from a handkerchief, or that of NH_3.

61. BLEACHING WITH CHLORINE.

Ch.: 2 rec. Cl, small piece Turkey red cloth, writing and printing on paper, leaf (or colored flower).

1. Suspend in a rec. of Cl a small piece of wet Turkey red cloth, also a dry piece.
2. Try the bleaching action of Cl on writing (wet).
3. Try the bleaching action of Cl on printing (wet).
4. Try the bleaching action of Cl on a leaf or colored flower.
5. Shake up a little H_2O with the gas, and try to bleach cloth by putting it into the water.
6. Account for any difference in 2 and 3, printing ink being colored by C (a mineral pigment), while writing ink contains a vegetable coloring matter. Turkey red is colored with madder.
7. State the theory of the chemistry of bleaching.

62. COMBUSTION IN CHLORINE.

Ap.: e.d., paper (unglazed).
Ch.: 3 rec. Cl, a little spirits of turpentine, a bit of Sb, As, or Cu (powdered), naphtha.

1. Charge 2 or 3 rec. with Cl by down. disp.
2. Dip some unglazed paper into oil of turpentine, $C_{10}H_{16}$, in an e.d.; warm it by holding near a flame for a minute, but do not set it on fire; then thrust it into a rec. of Cl. Explain the combustion. Reaction. Clean the rec. with naphtha or petroleum.
3. Sprinkle a pinch of finely powdered Sb, As, or Cu into a rec. of Cl. Reaction.

63. CHLORINE FROM SODIUM CHLORIDE.

Ap.: r.s., lamp, 2 t.t., d.t., rec.
Ch.: 1^{g} NaCl, 1^{g} MnO_2, 3^{cc} H_2SO_4.

1. Mix 1^{g} of fine NaCl and 1^{g} MnO_2, and add to them 2^{cc} H_2O and 3^{cc} H_2SO_4, in a t.t.
2. Pass a d.t. from this to a rec.
3. Heat, and notice the Cl gas.
4. $2\,NaCl + 3\,H_2SO_4 + MnO_2 = ?$ or
   $2\,NaCl + 2\,H_2SO_4 + MnO_2 = ?$

64. CHLORINE FROM BLEACHING-POWDER.

Ap.: small beaker (25 or 50^{cc}), large one (2000^{cc}).
Ch. : 5^{g} bleaching-powder, 10^{cc} H_2SO_4.

1. Put into a small beaker 5^{g} bleaching-powder, $CaCl_2 + Ca(ClO)_2$; set this in a large beaker, and hang in the latter the substance to be bleached.
2. Cover the large one with pasteboard, through which passes a thistle-tube into the smaller.
3. Pour through the thistle-tube 5^{cc} dilute H_2SO_4 (half water and half acid). Add more if needed.

65. CHLORINE WATER.

Ap.: 2 t.t.

Ch.: 3 or 4 crystals $KClO_3$, few drops HCl, 2^{cc} cochineal sol., 2^{cc} $K_2Cr_2O_7$ sol., Turkey red cloth.

1. Drop into a t.t. 3 or 4 crystals of $KClO_3$.
2. Add a few drops of HCl; hold in the flame for a minute, and when action begins add 5 or 10^{cc} H_2O.
3. Cautiously take the odor. The product is mostly HClO, etc., but it readily furnishes Cl.
4. To 2^{cc} cochineal sol. in a t.t. add a little Cl water. Is the solution bleached?
5. To 2^{cc} $K_2Cr_2O_7$ sol. in a t.t. add a little Cl water. Is this bleached?
6. $K_2Cr_2O_7$ is a mineral pigment; cochineal is animal. Explain the results.
7. Try to bleach a piece of Turkey red cloth by putting it into some Cl water.

66. TO MAKE BROMINE.

Ap.: r.s., lamp, 2 t.t., d.t., rec.
Ch.: 1^g KBr, 1^g MnO, 5^{cc} H_2SO_4, 5^{cc} HCl, cloth, etc. (to bleach).

1. Mix 1^g KBr crystals, and 1^g MnO_2; transfer them to a t.t., and add 3^{cc} H_2SO_4.
2. Attach a d.t. and pass the other end of it to the bottom of a t.t. surrounded by a rec. of water.
3. Hang the apparatus on a r.s., and heat it slowly. Avoid getting Br vapor into the air of the room, as it is very irritating to the eyes.
   $MnO_2 + 2\ KBr + 3\ H_2SO_4 = ?$
   $MnO_2 + 2\ KBr + 2\ H_2SO_4 = ?$
4. Notice the color of the gas and the liquid; also the sp. gr. of the gas, by pouring some into a rec. Test the bleaching action of this on cloth.
5. Sift a bit of fine Sb, As, or Cu into the gas, and look for combustion. Clean the t.t. by heating HCl with the residue.

67. TO MAKE IODINE.

Ap. : lamp, 2 t.t., rec., e.d., st.r.
Ch. : 1ᵍ KI, 1ᵍ MnO_2, 1ᵍ starch, paper, 3ᶜᶜ H_2SO_4.

1. Generate I in this experiment like Br in the previous one, substituting KI for KBr. Reactions.
2. Put 1ᵍ of fine starch into an e.d., add 2 or 3 drops of water, mix them; then pour on 5ᶜᶜ of boiling water from a t.t., and stir the mixture. This makes starch paste.
3. Dip some strips of paper into the starch sol., and save for testing I. Hold one in the I vapor of this experiment, and note the color imparted to it. This is the test for I. What would be the test for starch?

68. SUBLIMATION OF IODINE.

Ap.: t.t., st.r.
Ch.: 4 or 5 crystals I.

1. Warm 3 or 4 crystals of I in a dry t.t. Notice the color of the vapor, and its sp. gr., by pouring some of it into the air.
2. Hold a st.r. half way down the t.t. while warming the tube. Look for a sublimate on the sides of the t.t. and on the rod, and observe the crystals of I.

69. SOLUTION OF IODINE.

Ap.: t.t.
Ch.: few crystals I, 5cc C_2H_5OH, starch-papers.

1. Put 3 or 4 crystals of I into a t.t., and add 3 or 4cc alcohol, C_2H_5OH.
2. Warm a minute and observe the solution. This is tincture of I. Add a drop of this with a st.r., to a drop of starch sol. shaken up with 10 or 15cc H_2O. Observe the color. Boil it for a minute to see whether the color disappears. If not, too much I was added. Observe again when it is cool.
3. Try to dissolve 2 or 3 crystals of I in 2cc H_2O in a clean t.t. Warm it.
4. See whether any is dissolved, by using the starch test as above.

70. TEST FOR IODINE.

Ap.: 2 t.t.
Ch.: 5^{cc} KI sol., starch sol., $KClO_3$, HCl.

1. Prepare 5^{cc} Cl water (Exp. 65) in a t.t.
2. Put into a clean t.t. 5^{cc} KI sol., and add a drop of starch sol. Shake them well together.
3. Now add a drop or two of Cl water, and notice the change of color. Explain and give reaction.

71. CRYSTALLIZATION OF SULPHUR.

Ap.: 1 beaker (25 or 50^{cc}), r.s., plate, asbestus, lamp, e.d.
Ch.: 15^{g} S (brimstone), 3^{cc} HNO_3.

1. Into a small beaker put 15^{g} S, and slowly melt it over a lamp. Note the color.
2. When melted, extinguish the light, and leave the beaker in position till it is cool enough not to break. Then remove it and watch the solidification of the S. When half solid, pour out the res. into an e.d. of water.
3. Look for crystals of S in the beaker.
4. Loosen the S by pouring round the edges a little HNO_3. Warm if necessary, when the mass may be removed by a thin knife-blade.

72. ALLOTROPY OF SULPHUR.

Ap.: lamp, e.d., t.t.
Ch.: 10^g S, 3^{cc} HNO_3.

1. Put 10^g S into a t.t. and slowly melt it. Notice the yellow color, and see that the liquid is very thin. It is now somewhat above 100°.
2. Heat it more strongly till it becomes black. Note it is now very thick and cannot be poured. It is about 200°.
3. Apply more heat till it grows thin again. It is above 300°.
4. Now heat to boiling (over 400°), note the color of the vapor and any sublimate on the t.t.
5. Pour the S into an e.d. of water. Knead it, and note its elasticity. See that it afterwards changes.
6. Clean the t.t. as before.

73. HYDROGEN SULPHIDE.

Ap.: 2 t.t., d.t., filter paper, funnel.
Ch.: 5^{g} FeS, 5^{cc} HCl or H_2SO_4, few drops $Pb(C_2H_3O_2)_2$ sol., Ag and Cu coins, lit.

1. Put into a rec. or a t.t. 5^{g} FeS, 10^{cc} H_2O and 5^{cc} HCl (or H_2SO_4). Equation.
2. Adjust a d.t. and pass the gas, for a minute or two, into 5^{cc} H_2O in another t.t. Have the bearings tight.
3. See whether this sol. is acid, alkaline, or neutral. Use both colors of lit.
4. With a st.r. put a drop of the H_2S sol. on Ag and Cu coins. Reactions.
5. Put a drop of $Pb(C_2H_3O_2)_2$ sol. on paper, and hold it in the vapor of H_2S. This is the characteristic test for H_2S.

74. HYDROGEN SULPHIDE AS A REAGENT.

Ap.: H_2S gen.

Ch.: Sol. $AgNO_3$, $Pb(NO_3)_2$, $Ba(NO_3)_2$, Na_2CO_3 (4^{cc} each), H_2S.

1. Pour 2^{cc} $AgNO_3$ sol. into a clean t.t., add 5^{cc} H_2O, shake it, and pass a little H_2S gas into it. Reaction. What is the ppt.?
2. Do the same with $Pb(NO_3)_2$ sol. Equation.
3. Do the same with $Ba(NO_3)_2$ sol. Why is there no equation?
4. Mix 2^{cc} $Pb(NO_3)_2$ sol. and 2^{cc} $Ba(NO_3)_2$ sol., 5^{cc} H_2O; shake them and pass H_2S gas into the liquid for two or three minutes. Which metal is ppd.? Equation.
5. Filter, and add to the filtrate 2 or 3^{cc} Na_2CO_3 sol. What is the ppt.? Equation.

75. SPONTANEOUS COMBUSTION OF PHOSPHORUS.

Ap.: e.d.
Ch.: 10^{cc} CS_2, paper, P (size of pea).

1. Into an e.d. put 10^{cc} CS_2, and drop into it 2 or 3 small pieces of P. This is enough for a class. Notice the odor of CS_2, and the solubility of S.
2. Dip a piece of unglazed paper into the sol., hold it in the air till it is dry, and look for any action. Explain fully.

76. COMBUSTION UNDER WATER.

Ap. : t.t., rec., thistle-tube.
Ch. : few crystals $KClO_3$, 3^{cc} H_2SO_4, P (usual size).

1. Put into a t.t. 4 or 5 crystals of $KClO_3$ and 3^{cc} H_2O, and a bit of P, half the size of a pea.
2. Rest the t.t. in a rec., then slowly add 2 or 3^{cc} H_2SO_4, through a thistle-tube watching for any combustion. Explain.

77. SUBLIMATION OF ARSENIC.

Ap.: i.t. (10^{cm} long, $\frac{1}{2}^{cm}$ diam.), lamp.
Ch.: As_2O_3 (very small bit), charcoal (fragment).

1. Prepare a small, pointed i.t., and put into the bottom a bit of As_2O_3, not larger that a grain of wheat.
2. Above this, at a little distance, insert a fragment of charcoal.
3. First heat the coal to redness, then heat the As_2O_3 so the fumes will go over the hot coal. Note the odor of the escaping As. Keep the coal hot.
4. Look for a sublimate (metallic mirror) above the coal.
5. Break the tube with a jet of water, and examine the sublimate. What is it? Equation.

78. TO MAKE SILICA FROM WATER GLASS.

Ap.: e.d., r.s., lamp, st.r.
Ch.: 5^{cc} Na_4SiO_4, 5^{cc} HCl, 10^{cc} NaOH sol.

1. Put into an e.d. 5^{cc} Na_4SiO_4 (or K_4SiO_4), and add the same volume of HCl. Describe the effect. $Na_4SiO_4 + 4\,HCl = ?$
2. Pour off any excess of HCl, and evaporate the residue over a flame or a water-bath. $H_4SiO_4 - 2\,H_2O = ?$
3. When the residue becomes white, cool it, add 10^{cc} H_2O, and stir it for a minute; then taste a drop, and pour off the water.
4. What is the residue? Crush a little with the fingers, and compare it with any substance you have seen before.
5. Remove any that adheres to the e.d. with strong NaOH sol., by boiling. SiO_2 is soluble in NaOH sol.

79. GUNPOWDER.

Ap.: lamp, brick.
Ch.: 4^g KNO_3 (or $NaNO_3$), $\frac{1}{2}^g$ S, $\frac{1}{2}^g$ charcoal.

1. Pulverize separately and very finely 4^g KNO_3 (or $NaNO_3$), $\frac{1}{2}^g$ S, $\frac{1}{2}^g$ charcoal, and mix them intimately on paper or in a mortar.
2. Pile the mixture on a brick, and apply a lighted match. $2\,KNO_3 + 3\,C + S = ?$
3. Remove the adhering product by soaking in water.

80. ACTION OF SOAP ON HARD WATER.

Ap.: t.t., e.d.
Ch.: 2^g hard soap, 10^{cc} $CaSO_4$ (or $MgSO_4$) sol.

1. Dissolve in a t.t., by boiling 1 or 2^g hard soap in 10 or 15^{cc} H_2O.
2. Add 10^{cc} of a clear solution of $CaSO_4$ or $MgSO_4$ (recently made), shake it, and look for a ppt. or any turbidity. An insoluble lime-soap has been formed.
3. Sodium $\left\{\begin{matrix}\text{stearate}\\\text{palmitate}\\\text{oleate}\end{matrix}\right\}$ + calcium sulphate = ?

   From this explain the action of hard water on soap.

81. COMBUSTION OF MAGNESIUM.

Ap.: lamp, forceps.
Ch.: Mg ribbon (3^{cm}).

1. Examine a piece of Mg ribbon, and describe, noting any tarnish.
2. With the forceps hold it in a flame till it begins to burn. Notice the color and intensity of the light.
3. Observe the product, and name it. Equation.

82. COLORING BY A MORDANT.

Ap.: t.t.

Ch.: 20^{cc} $K_2Al_2(SO_4)_4$ sol., 10^{cc} NaOH sol., 2^{cc} cochineal sol.

1. To 10^{cc} $K_2Al_2(SO_4)_4$ sol. add 5^{cc} NaOH sol. Shake it. If too much is added, the ppt. dissolves.
2. Observe the character and color of the ppt. It is $Al_2(OH)_6$.
3. Try it again, adding 2^{cc} of cochineal sol. before putting in the NaOH. Notice that the $Al_2(OH)_6$ has appropriated the coloring matter.

83. TO OXIDIZE FERROUS TO FERRIC SALTS (Fe^{II} to Fe^{IV}).

Ap.: 2 t.t.
Ch.: 10cc $FeSO_4$ sol., 5cc NaOH or NH_4OH, 1cc HNO_3.

1. Into each of 2 t.t. put 5cc $FeSO_4$ sol. (recently prepared).
2. To one of these add 1cc HNO_3, and boil a minute.
3. Add to each 5cc NaOH sol. or NH_4OH. Reactions.
4. Explain the oxidation and the difference of colors, and see whether either hydrate tends to change to the other by standing. $FeSO_4$ has been oxidized to $Fe_2(SO_4)_3$.

84. TO REDUCE FERRIC TO FERROUS SALTS (Fe^{IV} to Fe^{II}).

Ap.: 4 t.t., d.t.
Ch. : 5cc $FeSO_4$ sol., HNO_3, NH_4OH, 2g Cu, 5cc H_2SO_4.

1. Oxidize 5cc $FeSO_4$ sol. with 1cc HNO_3, by boiling, as in Exp. 83, and dilute it with its volume of water.
2. Pour a little of this into another t.t., add to it NH_4OH, and note the color of the ppt.
3. Pass SO_2 gas from a gen. (Cu and H_2SO_4 heated in a t.t.), into the other portion for a few minutes.
4. Next add NH_4OH, and note the color of the ppt. Compare it with the previous product. $Fe_2(SO_4)_3$ has been reduced to $FeSO_4$, if the action continued long enough.

85. TO MAKE LEAD SALTS.

Ap.: 3 t.t.

Ch.: 55cc $Pb(NO_3)_2$ sol., 5cc sol. of each of these: $(NH_4)_2S$, K_2CrO_4, H_2SO_4, KI, KBr, NaCl, NaOH, Na_2SO_3, Na_2CO_3, KCN, $K_4Fe(CN)_6$.

Add 5cc $Pb(NO_3)_2$ sol. to each of the following in a clean t.t. Give the color of each product, name it, and write the reaction for its production. State whether a ppt. is produced. Tubes may be cleaned with NaOH sol., by boiling, then washing thoroughly. Use a swab.

(*a*) 5cc $(NH_4)_2S$.
(*b*) 5cc K_2CrO_4 sol.
(*c*) 5cc H_2SO_4.
(*d*) 5cc KI sol.
(*e*) 5cc KBr sol.
(*f*) 5cc NaCl sol.
(*g*) 5cc NaOH sol.
(*h*) 5cc Na_2SO_3 sol.
(*i*) 5cc Na_2CO_3 sol.
(*j*) 5cc KCN sol.
(*k*) 5cc $K_4Fe(CN)_6$ sol.

86. TO SEPARATE SILVER FROM COPPER.

Ap.: 2 t.t., funnel, filter papers, rec.

Ch.: 5^{cc} sol. $AgNO_3$ and 5^{cc} sol. $Cu(NO_3)_2$, 5^{cc} HCl, H_2S gen.

1. Pour into a t.t. 5^{cc} $AgNO_3$ sol. and 5^{cc} $Cu(NO_3)_2$ sol. Shake them together.
2. Add HCl till no more ppt. continues to form, then pour it on a filter. Save the filtrate. Reaction for $AgNO_3$. $Cu(NO_3)_2$ is unchanged.
3. See whether all the Ag is ppd. by adding 2 or 3 drops of HCl to the filtrate. If a ppt. occurs, add more, and filter again.
4. Note what the *residue* is, and what the *filtrate* contains.
5. Pass into the filtrate some H_2S gas. (Exp. 73.) Reaction. This ppts. CuS.
6. Filter. What is the residue? What metals have been separated?

87. TO ILLUSTRATE PHOTOGRAPHY.

Ap.: 2 t.t., filter paper, funnel, st.r., rec.
Ch.: 2^{cc} $AgNO_3$ sol., 4^{cc} NaCl sol., 10^{cc} $Na_2S_2O_3$ sol.

1. Put into each of 2 t.t. 10^{cc} H_2O, 1^{cc} $AgNO_3$ sol., and 2^{cc} NaCl sol.; shake, and notice the color. What is the product? Reaction.
2. Filter one of them, and wash the residue well with water, by pouring water on it, and allowing the water to run through the filter. Reject the wash-water. Then open the filter paper, and expose the residue to direct sunlight. Presently stir it, and observe the change of color produced by the light. $2\,AgCl - Cl = ?$
3. Add to the other portion 5^{cc} $Na_2S_2O_3$ sol. Shake it, and notice whether the ppt. dissolves. If not, add more *hypo*.

88. TO ILLUSTRATE PHOTOGRAPHY.

Ap.: 2 t.t., filter paper, funnel.
Ch.: 2^{cc} $AgNO_3$ sol., 4^{cc} KBr sol., 10^{cc} $Na_2S_2O_3$ sol.

1. Put into each of 2 t.t. 10^{cc} H_2O, 1^{cc} $AgNO_3$ sol., and 2^{cc} KBr sol. Shake, and filter the contents of one, and wash the residue. Reaction. Expose to direct sunlight, and observe the change of color. $2\,AgBr - Br = ?$
2. To the other add $Na_2S_2O_3$ sol. till the ppt. dissolves.

89. DESTRUCTIVE DISTILLATION OF WOOD.

Ap.: lamp, plate, i.t. (10^{cm} long, 1 or 1½^{cm} diam.).
Ch.: wood shavings.

1. Half fill an i.t. with wood shavings closely packed.
2. Hold it steadily over a lamp to heat it, meantime trying to ignite the escaping gas. Note the color of the flame, and see whether any soot is deposited on an e.d. held in the burning gas.
3. Break, and examine the tube for a tarry residue, and for coal.
4. Put the coal on an iron plate and bring a Bunsen flame in contact with it, noting whether it burns with a flame, or only glows. Only gas burns with flame.
5. Write no reactions, but state how many and what products you observed in this experiment.

90. ILLUMINATING GAS.

Ap.: i.t. (10^{cm} long, 1 or $1\frac{1}{2}^{cm}$ diam.), lamp, plate.
Ch.: 5^{g} cannel coal (granular masses).

1. Fill an i.t. $\frac{1}{3}$ full of cannel (or bituminous) coal.
2. Perform this experiment like the previous one, apply the same tests throughout, and notice and describe all the products. Heat strongly and as long as any gas separates.

91. ALCOHOL.

Two pupils may work together.

Ap.: apparatus for distilling, t.t., d.t., flask.
Ch. : 20cc molasses, half a cake of yeast.

1. Put 20cc molasses into a flask (of 200cc), fill it with water to the neck, and put in half a cake of yeast.
2. Fit to it a d.t., and pass the end into a t.t. holding some clear lime water. Leave it in a warm place for two or three days.
3. Look for any turbidity in the lime water, *and* account for it. See whether the liquid in the flask is sweet.
4. Attach the flask to an apparatus for distilling water, and pass over not more than one-fifth of the liquid by distillation.
5. Taste and smell the distillate. Re-distil it if desired, passing over not more than half of it.

92. VEGETABLE PARCHMENT.

Ap.: e.d.
Ch.: 12cc H_2SO_4, filter papers.

1. Pour into an e.d. 5cc H_2O, add 12cc H_2SO_4 (measure each), and stir the mixture.
2. *When it becomes cold*, dip a strip of unglazed paper (filter paper) into the liquid, and leave 15 seconds. One end of the paper should be out of the liquid, in order to remove it quickly.
3. At once rinse it thoroughly with water, then let it dry.
4. If the fibre is not toughened, try again, using new paper and varying the time a little.

93. ANALYSIS OF A SILVER COIN.

Ap.: e.d., lamp, H_2S gen.
Ch.: ten-cent coin, 5^{cc} HNO_3, 20^{cc} HCl, 5^{g} FeS.

1. Put a ten-cent Ag coin into an e.d., and pour over it a mixture of 5^{cc} HNO_3 and 10^{cc} H_2O. Warm it till all or nearly all has dissolved.
2. Remove any that is undissolved, and pour the liquid into a t.t. Add HCl as long as a ppt. continues to form, then filter. AgCl is the residue. Reaction.
3. Add a drop or two of HCl to the filtrate, and, if a ppt. falls, add more, and filter again, to remove all the Ag.
4. Pass H_2S gas into the filtrate so long as a ppt. forms. This is CuS. Reaction. Filter. The coin is thus found to contain Ag and Cu. This experiment is an example of qualitative analysis.

94. ANALYSIS OF TIN-FOIL.

Ap.: 3 or 4 t.t., lamp.
Ch.: HNO_3, HCl, H_2SO_4, K_2CrO_4 sol., $(NH_4)_2S$, HNa_2PO_4 sol., tin-foil.

1. Cover a small piece of tin-foil in an e.d. with 1 part HNO_3 to 2 parts water, enough to dissolve it, or nearly so. Warm the mixture.
2. Filter if necessary, and add its bulk of H_2O to the filtrate, then slowly add HCl till no more ppt., $PbCl_2$, falls. Filter and set aside the filtrate (for 4). Reaction.
3. Pour boiling water on the residue, and let it run through into a clean t.t. If it is not clear, boil a minute, then divide it into two parts. To one add a little K_2CrO_4 sol.; to the other add H_2SO_4. The ppts. are $PbCrO_4$ and $PbSO_4$. These prove the presence of Pb. Reactions.
4. To the filtrate (from 2) add a little $(NH_4)_2S$. Ppt. is SnS. Reaction. To prove it is Sn, filter, and pour on a little boiling HCl, which dissolves the SnS. Then boil away to one-third its volume, add its volume of H_2O or more, then add HNa_2PO_4. Ppt. is $Sn_3(PO_4)_2$.
5. What two metals (at least) does tin-foil usually contain? Some foil contains only Sn.

95. ANALYSIS OF FIRST GROUP METALS.

Ag, Pb, Hg (ous).

Ap.: 3 t.t., funnel, filter, lamp, rec.
Ch.: 2^{cc} sol. each $AgNO_3$, $Pb(NO_3)_2$, $HgNO_3$; also some HCl, K_2CrO_4 sol., NH_4OH, HNO_3.

1. Mix a sol. of $AgNO_3$, $Pb(NO_3)_2$, $HgNO_3$ (1^{cc} each) in a t.t.
2. Add slowly, dilute HCl (1 vol. HCl to 4 vol. H_2O) till the ppt. does not increase; shake, then filter. Ppt. contains AgCl, $PbCl_2$, HgCl. Reactions.
3. Throw away the filtrate, and add *boiling* H_2O (10^{cc}) to the residue, and let it run through the filter. Repeat this 3 or 4 times. This dissolves $PbCl_2$, and leaves the others. Catch the *filtrate*, and add to it 5^{cc} of a sol. of K_2CrO_4. This ppts. $PbCrO_4$. Color and reaction.
4. Pour on the *residue* (containing AgCl and HgCl) 5^{cc} NH_4OH. Catch the filtrate in a clean t.t. HgCl becomes black NH_2Hg_2Cl. AgCl is dissolved.
5. To the *filtrate* add 5^{cc} HNO_3. AgCl is ppd., being insoluble in acids.

96. ANALYSIS OF SECOND GROUP METALS. DIV. A.

Hg(ic), Bi, Cu.

Solutions: $HgCl_2$, $BiCl_3$, $Cu(NO_3)_2$.
Reagents: H_2S, dil. HNO_3, HCl, $SnCl_2$ sol., NH_4OH, $HC_2H_3O_2$, $K_4Fe(CN)_6$ sol.

1. Into 5^{cc} of a mixture of the above sol. pass H_2S gas to saturation. Filter; test the filtrate with H_2S, and, if there is no action, reject it. If a ppt. falls, continue and filter as before. Ppt. is HgS, Bi_2S_3, CuS. Wash the residue several times, or till the filtrate is neutral to lit. Reject the wash water.
2. Open the filter paper, and remove the res. with a spatula to an e.d.; cover it well with *dilute* HNO_3(4 H_2O to 1 HNO_3); boil it a minute. The insoluble res. is HgS and S. Sol. contains $Bi(NO_3)_3$, $Cu(NO_3)_2$. S is set free. Decant it upon a filter, leaving the res. in the e.d.
3. Cover the res. with aqua regia newly made, and stir it. Sol. contains $HgCl_2$. The insoluble mass is S. Filter, and add to the filtrate $SnCl_2$ sol. Ppt. is white HgCl or gray Hg.
4. To the filtrate (from 2) add NH_4OH to alkaline reaction. Ppt. is flaky $Bi(OH)_3$. The filtrate contains $Cu(NO_3)_2$. The blue color indicates Cu. Acidify the filtrate with $HC_2H_3O_2$ (take the odor after shaking), and then add $K_4Fe(CN)_6$ sol. The red or chocolate ppt. is $Cu_2Fe(CN)_6$.

97. ANALYSIS OF SECOND GROUP METALS. DIV. B.

As, Sb, Sn.

Solutions: Na_3AsO_3, $SbCl_3$, $SnCl_2$.
Reagents: H_2S, HCl, $KClO_3$, NH_4OH, $MgSO_4$ sol., HNa_2PO_4 sol.

1. If a ppt. (SbOCl, etc.) occurs in mixing the solutions, add a little HCl till it clears on shaking. *Saturate* 5^{cc} of the mixture with H_2S. Ppt. is As_2S_3, Sb_2S_3, SnS_2.
2. Filter, wash several times with hot water, remove res. to an e.d., add HCl, and boil a few minutes. Sol. contains $SbCl_3$, $SnCl_2$. Yellow res. is As_2S_3. Decant upon a filter, leaving res. in the e.d.
3. Cover the res. with HCl, add two or three crystals of $KClO_3$, and boil. Sol. contains $AsCl_3$. Filter, and add to filtrate NH_4OH and $MgSO_4$. Ppt. is NH_4MgAsO_4.
4. Boil filtrate (from 2) to a *very* small volume, to remove the free acid. Dilute it with water, and, if a ppt. falls, add a drop or two of HCl till it clears on shaking. Then add excess of HNa_2PO_4. Ppt. is $Sn_3(PO_4)_2$.
5. Filter, and add H_2S to the filtrate. Orange ppt. is Sb_2S_3.

98. ANALYSIS OF THIRD GROUP METALS.

Fe, Cr, Al.

Solutions: $FeSO_4$, $K_2Cr_2O_7$, $K_2Al_2(SO_4)_4$.

Reagents: NH_4OH, HNO_3, HCl, $KClO_3$, $HC_2H_3O_2$, C_2H_5OH, sol. of NaOH, and of $Pb(C_2H_3O_2)_2$.

To 2^{cc} of the $FeSO_4$ sol. add a few drops of HNO_3, and warm. Notice change of color. It has been oxidized to $Fe_2(SO_4)_3$. To 2^{cc} of the $K_2Cr_2O_7$ sol. add a few drops of HCl and of C_2H_5OH, and carefully boil a moment. Notice change of color. $K_2Cr_2O_7$ has been reduced to Cr_2Cl_6. When cool, mix these solutions, and add 2^{cc} $K_2Al_2(SO_4)_4$ sol.

1. To the mixture add excess of NH_4OH. Ppt. is $Fe_2(OH)_6$, $Cr_2(OH)_6$, $Al_2(OH)_6$. Filter and wash.
2. Pour on the residue a little HNO_3, and catch the filtrate in a t.t. $Fe_2(NO_3)_6$, $Cr_2(NO_3)_6$, $Al_2(NO_3)_6$, are formed and dissolved.
3. Boil the filtrate in a t.t., with a few crystals of $KClO_3$ until it is distinctly red, adding water if necessary. Shake the t.t. vigorously while boiling. This changes $(Cr_2NO_3)_6$ to $K_2Cr_2O_7$, and prevents ppn. of Cr in 4 and 5.
4. Add *excess* of NaOH sol. Red ppt. is $Fe_2(OH)_6$. Filter.
5. *Acidify* filtrate with HCl; then alkalize with NH_4OH. White flaky ppt. is $Al_2(OH)_6$.
6. Filter, acidify filtrate with $HC_2H_3O_2$, and add $Pb(C_2H_3O_2)_2$ sol. Reddish yellow ppt. is $PbCrO_4$.

99. ANALYSIS OF FOURTH GROUP METALS.

Zn, Mn, Co, Ni.

Solutions: $ZnSO_4$, $MnCl_2$, $Co(NO_3)_2$, $NiSO_4$.
Reagents: $(NH_4)_2S$, HCl, HNO_3, NaOH sol., $HC_2H_3O_2$, KNO_2 sol.

1. To 5^{cc} of a mixture of the above solutions add excess of $(NH_4)_2S$, and warm it without boiling. Ppt. is ZnS, MnS, CoS, NiS. Pour a little $(NH_4)_2S$ on the ppt., and at once wash it with hot water.
2. Transfer the res. to an e.d., pour on it dilute HCl, stir it well, then filter and wash. Zn and Mn are dissolved as chlorides. Res. is CoS and NiS.
3. Remove res. from 2 to an e.d., and dissolve in a little aqua regia. CoS and NiS are dissolved as chlorides. Filter if necessary. Add to the filtrate excess of NaOH sol. Ppt. is $Co(OH)_2$ and $Ni(OH_2)$. Filter. Pour on the residue $HC_2H_3O_2$. This dissolves them. Add KNO_2 sol. Yellow ppt. is $K_6Co_2(NO_3)_{12}$, complete only after several hours.
4. Filter, and add to filtrate excess of NaOH sol. Light, flaky ppt. is $Ni(OH)_2$.
5. Boil the filtrate (from 2) to expel all H_2S, and add excess of NaOH sol. Brown ppt. is $Mn(OH)_2$.
6. Filter, acidify filtrate with $HC_2H_3O_2$, and add $(NH_4)_2S$. White ppt. is ZnS.

100. ANALYSIS OF FIFTH GROUP METALS.

Ba, Sr, Ca, Mg.

Solutions: $BaCl_2$, $SrCl_2$, $CaCl_2$, $MgCl_2$.
Reagents: NH_4OH, NH_4Cl, $(NH_4)_2CO_3$, $HC_2H_3O_2$, $K_2Cr_2O_7$, $(NH_4)_2SO_4$, $(NH_4)_2C_2O_4$, HNa_2PO_4.

1. To 5^{cc} of a mixture of the above solutions (which should be filtered if turbid) add a little NH_4OH and NH_4Cl sol., and then excess of $(NH_4)_2CO_3$ sol. Warm, filter, and wash with hot water. Ppt. is $BaCO_3$, $SrCO_3$, $CaCO_3$. Filtrate contains $MgCl_2$.
2. Pour on the ppt. $HC_2H_3O_2$, add $K_2Cr_2O_7$ sol., and filter. Yellow res. is $BaCrO_4$.
3. Add to filtrate NH_4OH till alkaline; then add $(NH_4)_2CO_3$ sol. White ppt. is $SrCO_3$ and $CaCO_3$. Filter, wash, and pour on the res. $HC_2H_3O_2$, which dissolves it.
4. Add to this a dilute sol. of $(NH_4)_2SO_4$. White ppt. (after standing for some time) is $SrSO_4$.
5. Filter, add to filtrate NH_4OH and $(NH_4)_2C_2O_4$. White ppt. is CaC_2O_4.
6. To the filtrate (from 1) add HNa_2PO_4. White ppt. is $Mg_3(PO_4)_2$.

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